NASS-APS First Joint Meeting, Charleston SC, April 1998

Thermal Characteristics and the Lumbar Disc: Evaluation of a Novel Approach to Targeted Intradiscal Thermal Therapy

Jeffrey A. Saal, MD; Joel S. Saal, MD; John Ashley, MS Menlo Park, CA

Introduction: Collagen fibrils shrink and remodel after exposure to specific temperature ranges. Thermal shrinkage of collagen to promote capsular stability has been shown to be effective for shoulder dislocations. Thermal properties of collagen should permit shrinkage and stiffening of the annular wall. Discogenic pain may be triggered by mechanical and/or chemical sensitization of annular nociceptors. Altering annular mechanics and thermo-coagulating annular nociceptors is feasible. Recent studies question the ability of global disc heating accomplished by a centrally placed intranuclear needle to produce posterior annular temperature gradients sufficient to raise posterior annular temperatures. This series of experiments was conducted to evaluate the feasibility of a novel, temperature controlled catheter to deliver targeted heat thermal across the posterior annular wall in a specified therapeutic range.

Materials and Methods: Part I: Human Cadaveric Bench Navigation Studies. Previously prepared human cadaveric lumbar spines were evaluated for intra-discal navigation. Five (5) cadaver spines totaling 20 usable discs were penetrated using a standard extrapedicular discographic approach, and the distance to the posterior wall measured, by dissection and direct visualization. None of the needle placements allowed access to the posterior zone. The failure of the needles to navigate posteriorly adjacent to the posterior annular wall, prompted the development of a semi-rigid catheter. The catheter was consistently able to navigate through the intra-nuclear cavity and be placed adjacent to the posterior annual/nuclear interface. Part II: Human Cadaveric Bench Thermal Application. Radiofrequency at 485 kHz was used intradiscally after successful placement of the needles into the center of the nuclear cavity (as per Part I). Consistently (20/20) the specimens could not be heated above 2-5 C due to the rapid rise of impedance. This led to the development of a thermal resistive coil (TRC). The TRC was able to raise the Intradiscal temperature 10+° without impedance difficulties. Part III: In-Vivo Animal Thermal Mapping Model. A live pig was prepared. General anesthesia with isofluorance was obtained and a postero lateral exposure was made. One disc level was analyzed. A thermal probe was placed intradiscally and thermocouples were placed adjacent to the posterior annular wall, the inferior and superior end plates, and the intranuclear cavity. The temperature was raised by 10° C across the posterior annular wall. Part IV: Human Cadaver C/T Guided Navigation Study. A previously prepared human cadaver underwent magnetic resonance imaging of the lumbar spine to locate an anatomically accessible disc. This disc was entered under C/T guidance with a specially designed semi-rigid navigable catheter, through a standard extrapedicular discographic approach. Axial C/T images confirmed the ability to navigate the catheter to the posterior annular wall. Part V: Volumetric Evaluation of Nuclear Shrinkage. A water displacement model was used to evaluate temperature distribution and degree of nuclear shrinkage. Catheter placement was undertaken under direct visualization, macro and volumetric evaluation of nuclear displacement was measured. Seven percent (7%) total nuclear shrinkage (by volume) and 20% of focal nuclear shrinkage (by volume) was noted.

Conclusions: It is not feasible to place a needle adjacent to the posterior annular wall at the nuclear interface corresponding to the four to eight o'clock zone. It is feasible to navigate with a semi-rigid catheter intradiscally within the nuclear cavity to achieve catheter placement adjacent to the posterior annular wall, at the four to eight o'clock zone. It is feasible to transfer heat across the annular wall and raise the temperature to >10° C with a thermal resistive coil. Radiofrequency was not a reliable heat source to accomplish intradiscal thermal application, due to impedance difficulties. TRC has no such difficulties and appears to be better choice for intradiscal targeted thermal ablation. Nuclear shrinkage can be accomplished with targeted thermal application. Temperature ranges necessary to thermo-modulate (shrink) collagen can be achieved with a navigable catheter system. Clinical studies are required to determine whether targeted thermal therapy is effective in the treatment of precisely diagnosed chronic discogenic lumbar pain.